

Citizen scientists significantly improve our knowledge on the non-native longhorn beetle *Chlorophorus annularis* (Fabricius, 1787) (Coleoptera, Cerambycidae) in Europe

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Abstract

The Asian bamboo borer *Chlorophorus annularis* is a beetle species that has been introduced in many countries globally. Originating in Southeast Asia, it can now be found in the Americas, South Africa, the Middle East, Australasia and Europe. The literature record of the species in Europe consists of findings of single individuals usually associated with imported bamboo products. A general European effort in surveying *C. annularis* was never undertaken, since the overall scientific consensus was that the species cannot establish here. Yet, recent records in Genk, Torhout (Belgium) and in Hamburg (Germany) do not seem directly associated with a recently imported product and hence may indicate otherwise. Such a shortfall in recording commonly imported, potentially invasive species may be counteracted through citizen science initiatives, allowing for continuous, high density monitoring. In this paper we present thirteen new records of the species from five European countries, including two new country records, mostly going back to interested citizen scientists.

Keywords

bamboo, Cerambycidae, Coleoptera, Hamburg, insect, invasion biology, neozoa, pest organism

Introduction

Non-native species, accidentally or purposefully introduced organisms, represent one of the big challenges in a globalized world (Kenis et al. 2009; Simberloff et al. 2013; Bellard et al. 2016; Bradshaw et al. 2016), with constantly rising numbers of newly recorded species (Hulme 2009; Seebens et al. 2017). These species, while often barely recognized, may represent severe economic and ecological threats (e.g. as agricultural pests, ecological competitors or predators of native species). However, despite their potentially high importance, surveying non-native species is still only performed for a limited number of highly invasive species, as it is time consuming and expensive. Including the general public in such surveying activities through citizen science initiatives and projects, or taxonomic interest groups and websites, may be a viable alternative (Gallo and Waitt 2011; Chandler et al. 2017). This approach has been proven to be powerful, for example, in demonstrating the decline of monarch butterflies (Schultz et al. 2017), and changes in ladybird populations (Gardiner et al. 2012) and has also been used to detect and monitor non-native species (Delaney et al. 2008; Crall et al. 2010, 2011).

While large invasive species, such as mammals, birds and fish, are detected more easily, smaller arthropod species often remain unspotted for some time after their introduction (e.g. Wolter and Röhr 2010; Fischer et al. 2016). Nevertheless, arthropods, and especially insects have high invasion potential and can often be detrimental pests (Kiritani and Yamamura 2003). Insects are frequently transported with raw materials, and agricultural products, or living plants and plant material. One of the groups specifically commonly introduced with plants and wood are the longhorn wood boring beetles of the family Cerambycidae (Eyre and Haack 2017).

The family comprises more than 40,000 described species worldwide, which are all phytophagous, xylophagous or saproxylophagous. Fortunately, only some species are true pests of economic importance. In the past, only species with a long life cycle and species capable of lasting several generations in the same host material could bear the long times of transportation and emerge in the countries of importation to generate a possible invasion. *Hylotrupes bajulus* (Linnaeus, 1758) (Cerambycinae, Callidiini) and *Nathrius brevipennis* (Mulsant, 1839) (Cerambycinae, Nathriini) were probably two of these invasive pioneers. A first synthesis of imported beetles in Europe was done by Duffy (1953). The growth of international trade, the reduction of the length of transport and the increase in diversity of potential vectors of longhorn beetles since the 20th century allowed an increase in the number of individuals and species accidentally imported, as shown by the numerous interceptions, introductions and establishments reported by national and international organizations (e.g. EPPO (in European Union), APHIS (in United States of America), AQIS (in Australia) and Biodiversity (in New Zealand), over the past four decades. Despite international sanitary and control measures, many new potential invasive cerambycids reach foreign areas on a regular basis (e.g. Cocquempot 2007; Cocquempot and Lindelöw 2010). While interceptions have become common, sometimes introductions may occur unrecognized, but rarely

species are able to establish. Within the longhorn beetles, the Asian longhorn beetle (*Anoplophora glabripennis* (Motschulsky, 1853)) (Lamiinae, Monochamini) is among the most feared. The species originates in Central Asia, but has been introduced in North America and Europe, where it attacks a diverse range of trees (Meng et al. 2015). Other introduced cerambycids include the Citrus longhorn beetle (*Anoplophora chinensis* (Forster, 1771)), or the Red-necked longhorn beetle (*Aromia bungii* Falderman, 1835) (Cerambycinae, Callichromatini). Newly imported cerambycid species are constantly reported (e.g. Friedman et al. 2008; Burmeister et al. 2012; Cocquempot et al. 2015a, b; Sarto i Monteys and Torras i Tutusaus 2018).

One of the species of longhorn beetles that is more frequently intercepted is the Bamboo borer *Chlorophorus annularis* (Fabricius, 1787) (Cerambycinae, Clytini). This beetle originally inhabits temperate to subtropical regions of Southeast Asia (native range: Cambodia, China, India, Indonesia, Japan, Korea Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam (Monné 2005; Cocquempot 2007; Friedman et al. 2008)). It has been reported to attack species of fourteen different plant families: Aceraceae, Anacardiaceae, Betulaceae, Dipterocarpaceae, Hamamelidaceae, Juglandaceae, Lamiaceae, Malvaceae, Mimosaceae, Paeoniaceae, Poaceae, Rosaceae, Ulmaceae, Vitaceae (for genera and species see Monné 2005). Most notable is the damage the species is causing to bamboo, which is the main product it is contaminating outside of its natural range. So far, it has been intercepted in the Middle East (Israel: Friedman et al. 2008), South Africa (Suma and Bella 2018), South America (Brazil: Monné 2005; Uruguay: Suma and Bella 2018), North America (United States: Mattson et al. 1994; Eyre and Haack 2007; Canada: NAPPO 2014), Australasia (Australia: Hanks et al. 1997; New Caledonia: Suma and Bella 2018; New Zealand: MPI 2013) and ten European countries (Cocquempot 2007; Suma and Bella 2018). The first European specimen was captured in the United Kingdom in 1924, followed by records in Finland and Czech Republic in 1936 and subsequently in Germany, Austria, Spain, Hungary, France, Denmark and Italy (for map and references see Fig. 2 and Table 1). So far, the species is only regarded as invasive in Spain with the potential to get established in other Mediterranean areas as well (Vives 1995; Cocquempot and Lindelöw 2010). Here we report *Chlorophorus annularis* as newly intercepted to the Netherlands and Belgium, as well as the first traceable record for Denmark. For Czech Republic, France, Germany and the United Kingdom, new records are presented, mostly based on records from citizen scientists.

Materials and methods

Physical specimens examined

One specimen (ZMH 83366): „aus Tonkin Frühjahr 1953 eingeführt, *Chlorophorus annularis* F. Dr. E. Franz det. 1953“; two specimens (ZMH 833668, ZMH 833668): „Aschaffenburg aus Bambus Blumengest[ell], IX.59“; one specimen (ZMH 833670):

Table 1. Records of *Chlorophorus annularis* in Europe sorted by country and date of introduction.

Locality	Date	Origin	Reference
Austria			
Vienna	July 1993		Schillhammer (1994)
Judenburg	December 1997	bamboo furniture	Adlbauer (2001)
Klagenfurt	no date	Bamboo	Steiner (1997)
Belgium			
Genk	July 2019	inside car with no host plant association	https://www.inaturalist.org/observations/39960166 (accessed 27.10.2020); new record (this paper)
Torhout	December 2020	inside house with no host plant association	new record (this paper)
Czech Republic			
Brno	1936	Bamboo	Sláma (1998)
Brno	between 1930 to 1951	Bamboo	Heyrovský (1951)
Prague	between 1930 to 1951	Bamboo	Heyrovský (1951)
Horní Počernice	ca. 2000	Bamboo	new record (this paper)
Obříství	August 2016 to August 2018	bamboo poles imported from China via the Netherlands	new record (this paper)
Denmark			
Denmark	1974		Cocquempot (2007) (Com. pers M. Petersen)
Hesselager	July 2016	bamboo sticks	new record (this paper)
Finland			
Helsinki	February 1936	bamboo (ski poles)	Saalas (1940)
Helsinki	no date	Bamboo	Tuurala (1945)
France			
Saint-Georges-de-Didonne	July 1986	on flower of <i>Ligustrum</i> , probably emerged from bamboo lounge furniture	Hengoat (2008)
Saulx-les-Chartreux	August 2001 (date in Hanot (2006) incorrect [pers. comm. Hanot 2020])	on the street with no host plant association	Hanot (2006)
Betton	July 2001	inside the house	Gouverneur and Guérard (2011)
Mesquiers	August 2004	bamboo furniture imported from Vietnam	Cocquempot (2007)
Besse-sur-Issole	April 2008	bamboo furniture imported from Indonesia	new record (this paper)
Le Crès	April 2014	bamboo broomstick	new record (this paper)
Germany			
Hamburg	spring 1953	imported bamboo (“Tonkinrohr” = <i>Arundinaria amabilis</i>)	Weidner (1954); specimen in ZMH
Frankfurt am Main	May 1958	bamboo frame	Franz (1959)
Hildesheim	October 1958	bamboo pieces	Schmidt (1962)
Stuttgart	August 1959	bamboo stick	Harde (1959)
Aschaffenburg	September 1959	“Blumengestell”	Weidner (1982); specimen in ZMH
Aschaffenburg-Schweinheim	April 1965		Elbert (1969)
Hamburg, Billwerder	October 1965	hatched from bamboo railing	Weidner (1982)
Niederlinxweiler	1967	bamboo	Stock (2001), Niehuis (2001)
Hamburg	August 1991	bamboo sofa imported from Bali	new record (this paper); specimen in ZMH
Roth	April 2001		Stock (2001)
Karlsruhe	October 2004 – May 2005	bamboo furniture	Riedel (2005)
Schmira	October 2005	imported bamboo sticks	Kopetz et al. (2008)
Hamburg	August 2020	on wooden fence in close proximity to ornamental bamboo plant	new record (this paper)
Hungary			
Budapest	May 2008	bamboo	Kovács (2010)
Italy			
Catania	May 2018	bamboo ladder	Suma and Bella (2018)

Locality	Date	Origin	Reference
Netherlands			
Wageningen	August 2011	bamboo stick	https://waarneming.nl/observation/62023595/ (accessed 30.10.2020); new record (this paper)
Spain			
Sant Cugat del Vallès	September 1991	on flowers in an urban area with planted bamboo	Vives (1995)
United Kingdom			
Oxford? [=home of the author]	before 1924	bamboo pot imported from Myanmar	Poulton (1924)
London	no date	bamboo	Fisher (1942)
Princes Risboroug	October 1940 – October 1941	bamboo	Fisher (1942)
Buckenham Wood	no date		Cocquempot (2007)
Braintree	July 2018	suspected to be from bamboo from horticultural supplier	<i>iRecord</i> ; new record (this paper)
Lincoln	September 2019	bamboo sticks	https://www.inaturalist.org/observations/33252453 (accessed 27.10.2020); new record (this paper)
Stirchley	October 2020	bamboo	<i>iRecord</i> ; new record (this paper)

„Herkunftsland: Bali in BS aus Importsofa geschlüpft 8.8.1991“. All specimens are deposited in ZMH (Zoologisches Museum, Centrum für Naturkunde, Hamburg, Germany).

Citizen science

Firstly, the term ‘*Chlorophorus annularis*’ was entered in the search function of the citizen science platforms listed below. Secondly, all *Chlorophorus* species records were checked to exclude possible misidentifications with similar looking species.

iNaturalist (<https://www.inaturalist.org/>)

iRecord (<https://www.brc.ac.uk/irecord/>)

Entomologické Fórum (<http://www.entoforum.cz/>)

waarneming.nl (<https://waarneming.nl/> [Dutch version of observation.org])

Results

Corrections of previous records

The occurrence of the species from Romania was reported by Cocquempot (2007), but after further research for this paper, we noticed that it was a misinterpretation of a record from Czech Republic. So far, the species has not been recorded in the country (pers. comm. R. Serafim 2020). The specimen reported by Hanot (2006) in Saulx-les-Chartreux (France) was collected on the 12th of August 2001 and not as stated in the paper on 22nd of July 2002.

New Records

Belgium. A specimen was found alive in a car in Genk on the 31st of July 2019 and subsequently reported on *iNaturalist*. An association with a host plant could not be established. A specimen emerged in a house in Torhout (approximately 51.069, 3.101) on the 30th of December 2020 and was collected by Tineke De Blauwe. No apparent connection to a host plant could be established. The specimen was subsequently identified by Koen Verhoeyen (Deinze, Belgium) and Alain Drumont (Brussels, Belgium) and will be deposited in the Royal Belgian Institute of natural Sciences (Brussels, Belgium). These two finds represent the first records of the species for Belgium.

Czech Republic. Multiple specimens (Fig. 1A–C) were found alive in Obríství (approximately 50.294, 14.476) between August 2016 and August 2018 and subsequently posted in the *Entomologické Fórum* (a Czech entomological online forum). Broken bamboo poles inhabited by larvae and adults were found between June and August. Adults usually hatched in August. Along with *Chlorophorus annularis*, species of Anthribidae, Bostrichidae and Curculionidae were found (pers. comm. P. Jansa 2020). The specimens are deposited in the collection of Václav Hanzlík. A second occurrence of the species was recorded from Horní Počernice around the year 2000 by a local entomologist (pers. comm. P. Jansa 2020). The specimen came from a company that imports bamboo furniture and sticks and was collected at light in a warehouse window. Both new records are the first of the species in Czech Republic for over 60 years.

Denmark. Seven specimens hatched out of bamboo sticks in Hesselager on Funen Island (approximately 55.175, 10.744) between the 15th July and 15 August 2016. They were collected by Henning L. Hansen and identified by Jørn Misser. The find consisted of larvae in bamboo sticks imported from Vietnam out of which seven adults hatched. The specimens are preserved in the collection of Jørn Misser.

France. Several specimens hatched out of a bamboo bed inside a home in Besse-sur-Issole (approximately 43.339, 6.197) on the 17th of April 2008 and were collected by Jean-Yves Poirier-Baldovini. The bed was imported from Indonesia and exhibited multiple exit holes (Fig. 1D). A specimen hatched out of a bamboo broomstick from a workshop in Le Crès (approximately 43.643, 3.93) in April 2014 and was recorded by Jérôme Sudre. The broomstick exhibited multiple exit holes, but no more specimens were found. We assume that additional specimens escaped the location.

Germany. A specimen hatched out of an imported bamboo sofa in Hamburg on the 8th of August 1991. The specimen was imported from Bali (Indonesia) and subsequently deposited in the ZMH collection. A specimen (Fig. 1E) was recorded alive on the 23rd of August 2020 in a garden in Hans-Dewitz-Ring, 21075 Hamburg (Harburg) (53.4596, 9.9459) by Maren Lüttke. The specimen was found on a wooden fence in close proximity to a ca. 15-year-old ornamental bamboo plant. The specimen was not preserved and only recorded with a smartphone camera. This is the third record for Hamburg and the first since 55 years.

Netherlands. One specimen (Fig. 1F) was found in Wageningen, Gelderland (51.9877, 5.6673) on the 18th of August 2011 and subsequently reported on *waarne-ming.nl*. The specimen was found alive under a pile of bamboo sticks that was pur-

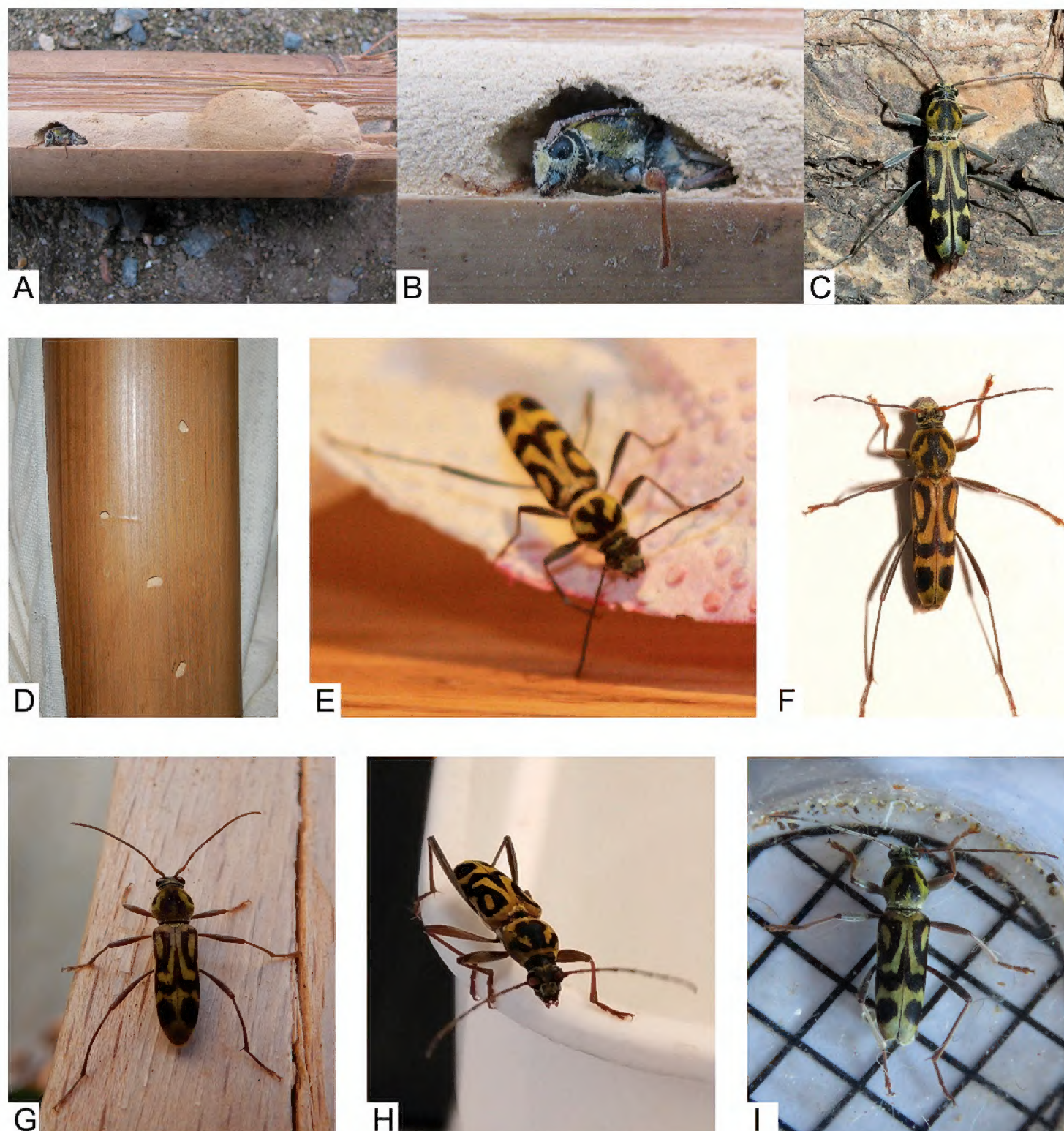


Figure 1. *Chlorophorus annularis* specimens and host plants of new records **A–C** Obříství, Czech Republic (photos by P. Jansa & V. Hanzlík) **D** Besse-sur-Issole, France (photo by J. Poirier-Baldovini) **E** Hamburg, Germany (photo by M. Lüttke) **F** Wageningen, the Netherlands (photo by D. Belgers) **G** Braintree, United Kingdom (photo by S. Rolls) **H** Lincoln, United Kingdom (photo by S. Cotter) **I** Stirchley, United Kingdom (photo by A. Slater) **A, B** emerging specimen from bamboo stick **C, E–I** emerged specimens **D** exit holes in bamboo furniture of Besse-sur-Issole specimens.

chased from a garden center (pers. comm. D. Belgers). This represents the first record of the species for the Netherlands.

United Kingdom. A specimen (Fig. 1G) was found alive in Braintree (approximately 51.903, 0.569) on the 1st of July 2018 and subsequently reported on *iRecord*. The specimen is suspected to have come from bamboo bought from a horticultural supplier. Another specimen (Fig. 1H) was found alive at Think Tank, Lincoln (approximately 53.228, -0.555) on the 23rd of September 2019 and subsequently reported on *iNaturalist*. The

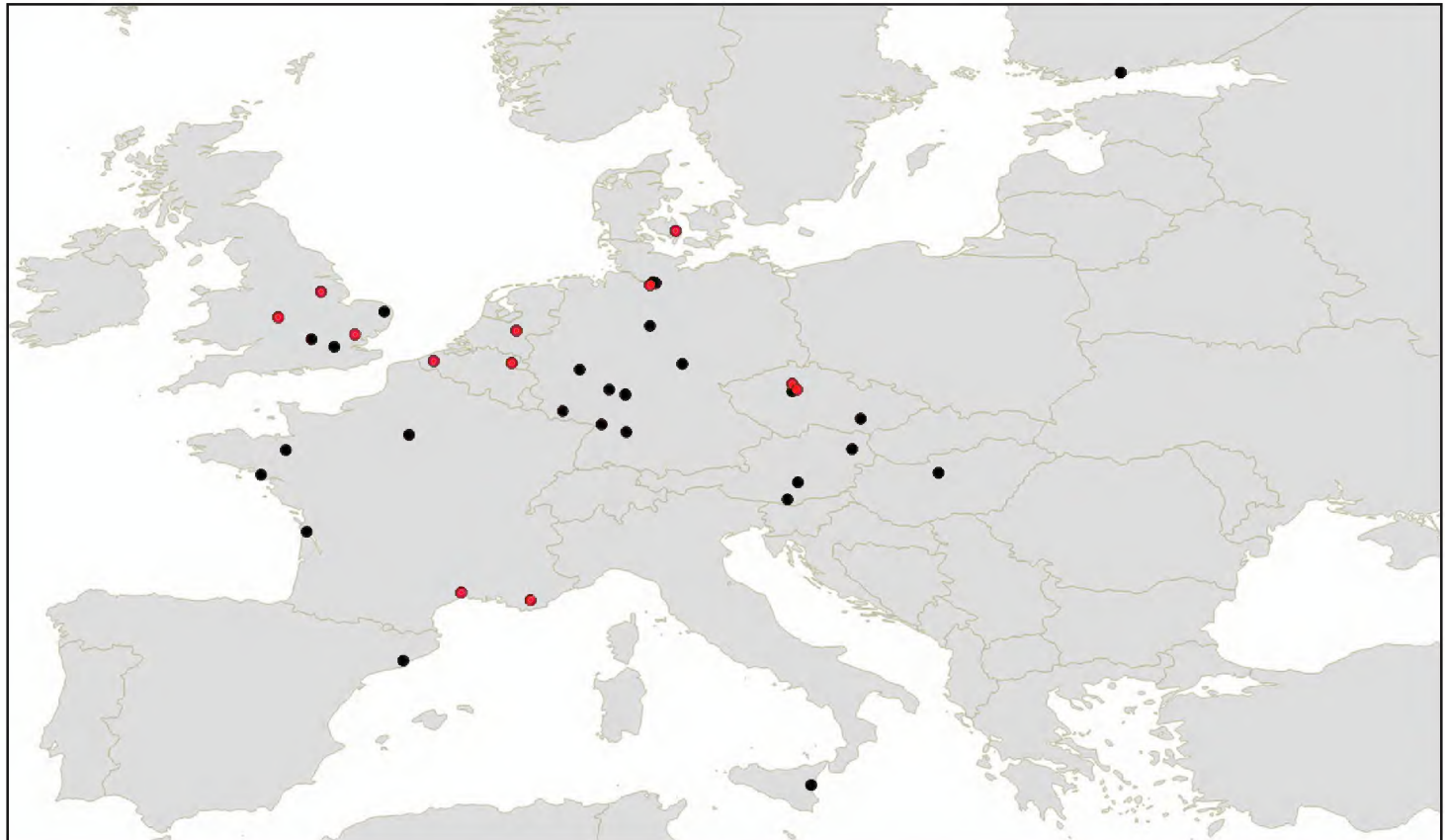


Figure 2. Occurrence of *Chlorophorus annularis* in Europe (red: new records; black: literature records).

specimen was found on a window and most likely came from a bundle of bamboo sticks stored in an office (pers. comm. Sheena Cotter). It was released outside after photography. A third specimen (Fig. 1I) was found alive in Newlands Road, Strichely (approximately 52.429, -1.913) on the 9th of October 2020 and subsequently reported on the *iRecord* App. The specimen was found in a garage, in which bamboo was stored (remark by Rob Tilling). These three records are the first to be recorded in over 13 years for the United Kingdom.

Discussion

We here present thirteen new records of *Chlorophorus annularis* from seven European countries including two new country records displaying the wide spread of this commonly overlooked non-native species. Most records were provided by citizen scientists, clearly displaying the impact of taxonomic interest forums and recording platforms such as *iNaturalist*, *iRecord* and *waarneming.nl* to provide data for rare and non-native species. Other social media platforms, such as Facebook, also provide an invaluable tool in biological recording of invasive species, as many records are sent into entomology and nature-themed groups, where both amateurs and scientists help in identifying them. The awareness raised by these citizen science tools may, in the future, even help to act as an early warning system for invasive species.

Despite custom controls at import sites, like harbors and airports by national plant protection services and despite international standards for the importation of products and wood packaging, more and more invasive species arrive in Europe and are intercepted (see all Pest alerts from **European Plant Protection Organization** (EPPO/OEPP)). However,

even more accidental imports remain undetected or are discovered only years after the introduction, potentially facilitating the establishment of detrimental species. This may also be true in the case of *C. annularis*, which resembles local species across Europe and hence may often be mistaken and not recognized. Therefore, the number of specimens reaching Europe every year likely remains grossly underestimated. This may also explain, why the species so far has not been reported from the Scandinavian Peninsula, Balkan countries and European countries east of Germany (Czechia, Austria and Hungary). Similarly, Portugal, Switzerland and Ireland in western and Central Europe currently lack records. Yet, it remains likely that the species is also imported into these countries via the bamboo trade. While the species has been intercepted in many European countries, it is mostly represented by single or a few individuals, which are clearly associated with the substrate they were imported with, and hence are likely not established. However, current records from Genk, Torhout (Belgium) and Hamburg (Germany), where the species was found without direct association to an imported product, may indicate that *C. annularis* could establish in European countries other than Spain. However, due to a lack of data it is currently not predictable where. Furthermore, climate change may facilitate future establishment, where host plants are available. These conditions could be met in the major cities of southern Europe. Therefore, recent records in Sicily and in the Hérault and Var departments in southern France are concerning and should be further surveyed. One tool to do so may be directed citizen science efforts as recently done in several European countries, for example for the Asian hornet *Vespa velutina* or for non-native mosquitoes (Walther and Kampen 2017).

In order to use the power of citizen science for the monitoring of non-native species more effectively, two approaches may be specifically promising. On the one hand, specialized platforms introducing non-native species of interest to the general public and providing reporting tools may increase public awareness and also recording activities for these taxa. On the other hand, drawing records of specific non-native species of interest, which are flagged and regularly exported from other citizen science databases and platforms may help to provide a better overview of distributions of these taxa. Both approaches combined may be the most effective way to channel citizen science activities towards a better monitoring of non-native species.

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Yves Poirier-Baldovini (Bastia, France), Tineke De Blauwe (Torhout, Belgium), Koen Verhoeyen (Deinze, Belgium), Alain Drumont (Royal Belgian Institute of natural Sciences, Brussels, Belgium) and Jørn Misser (Østbirk, Denmark) for providing information on their records and allowing us to use their images.

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